Optimizing reliability of large wind turbine rotor blades

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LM Glasfiber – Present in all major markets

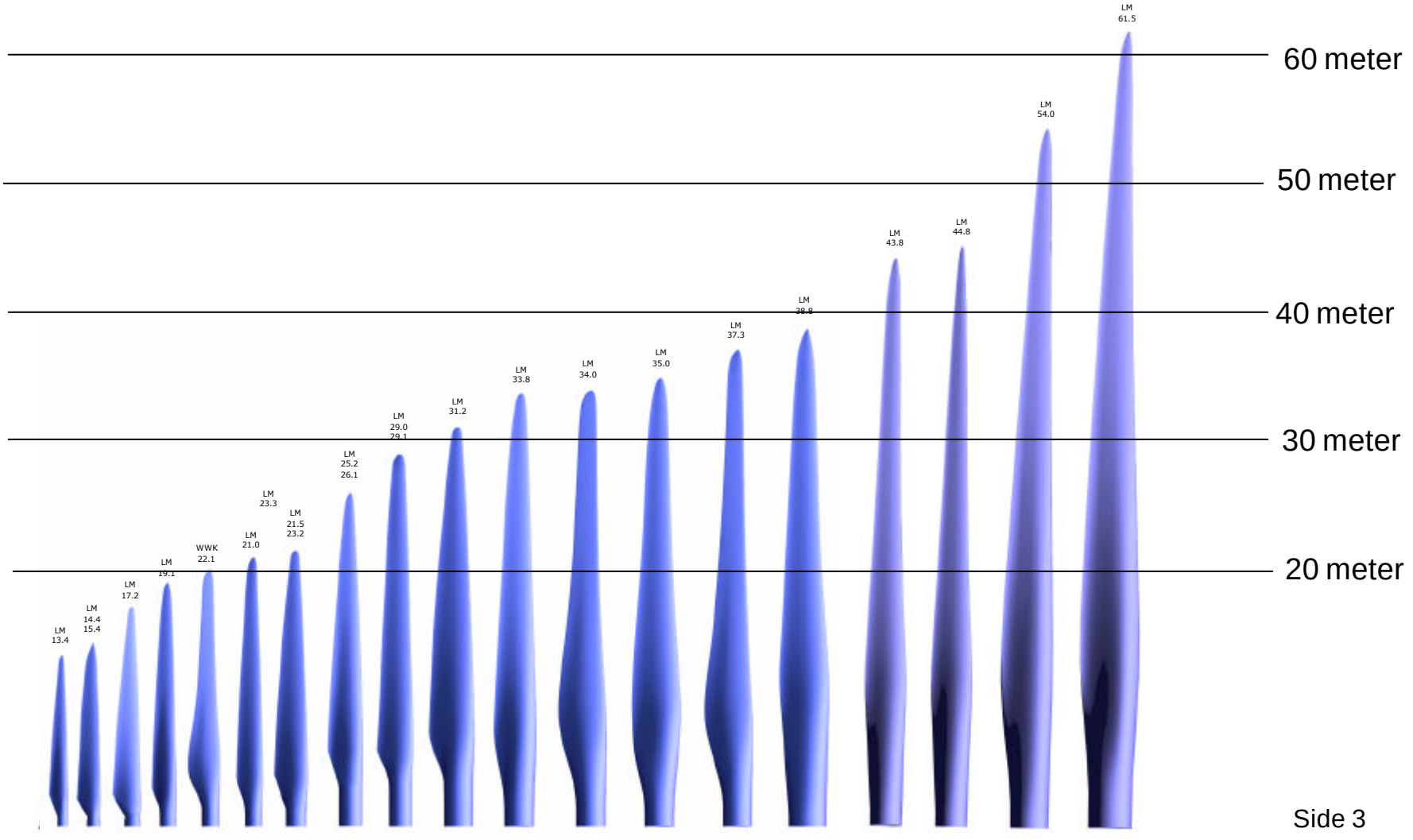
- Manufacturing and service facilities
- Under establishment

Segmentation of our global production capacity

	No. of plants	MW*	Planned extensions
Northern Europe	5	2,580	400
Southern Europe	3	1,700	
North America	1	680	
Asia	2	350	
Total	11	5,310	
MW supplied in 2002		2,705	
Average capacity utilisation		51%	

*The MW figures are based on the product mix for 2002

Product range - 300 kW to 5 mW



Lightning protection – 24 x 7 x 365

- 2000 thunder storms are active through out the world at any given moment producing approx. 100 flashes of lightning per second.
- Lightning releases currents of up to 200.000 amps released in a extremely short period of time

Selected lightning parameter		Protection level		
		1	2	3
Current peak value	I (kA)	200	150	100
Total charge	Qtotal (C)	300	225	150
Specific energy	W/R (kj/Ω)	10,000	5,600	2,500
Average stepness	kA/µs	200	150	100

Source: CEI/IEC 61024-1-1

LM Glasfiber Lightning Protection was developed and designed to conform with the international CEI/IEC protection level 1 standards.

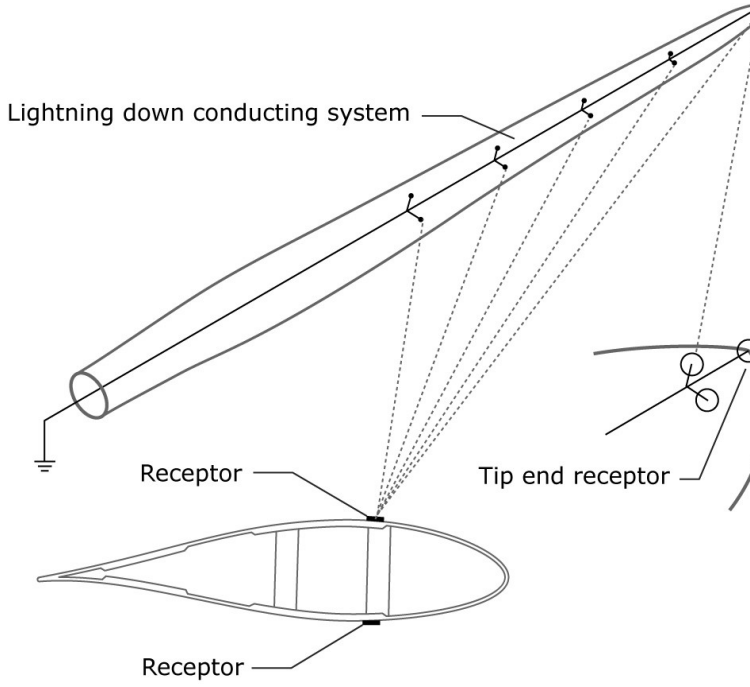
Lightning damage to blades

- Non-conducting blades without any conducting components are often struck by lightning and suffer major damage
- Statistics show that lightning causes 4 - 8 faults per 100 turbine years in northern Europe and up to 14 faults in southern Germany
- One third of the faults were caused by lightning strikes to turbines, the rest were due to power and telecommunication systems
- 7-10% of all lightning events involve wind turbine blades, which are the most expensive component to repair
- The above statistics cover a nine-year period from 1990 – 1998, mostly non lightning protected blades

Lightning features

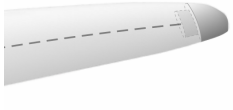
LM Lightning protection

- More than 40,000 blade supplied with lightning protection
- LM standard lightning protection cuts insurance costs
- New improved offshore lightning system has been developed according to the DEFU rec. nr. R25 for lightning protection of wind turbine blades
- New and more advanced standards for testing of lightning protection has been performed with success
- Future offshore projects will have to meet requirements of R25 and (US) SAE ARP5416 and (European) EUROCAE ED105 Aircraft lightning test standard



LM Lightning protection – continues improvements

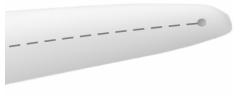
Tip-end receptor I
1. First generation
2. Site test



1994

First lightning protection system introduced by LM on the global market

Tip receptor
1. Development based on experiences from version 1
2. Test MIL–STD-1757A
3. Mounted in more than 40,000 blades.



1995

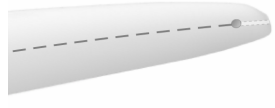
Solution for smaller blades

Multi receptor I
1. Tested in 2002 after new SAE/EUROCAE standard
2. Norm IEC61024-1

2000

Solution for larger blades

Tip end receptor II, with drainage inside the end receptor
1.Tested in 2002 after SAE/EUROCAE standard
2. Norm IEC61024-1



2001

Solution for all blades

Blades with carbon fibers
1.Tested in 2002 after SAE/EUROCAE standard
2. Norm IEC61024-1

2003

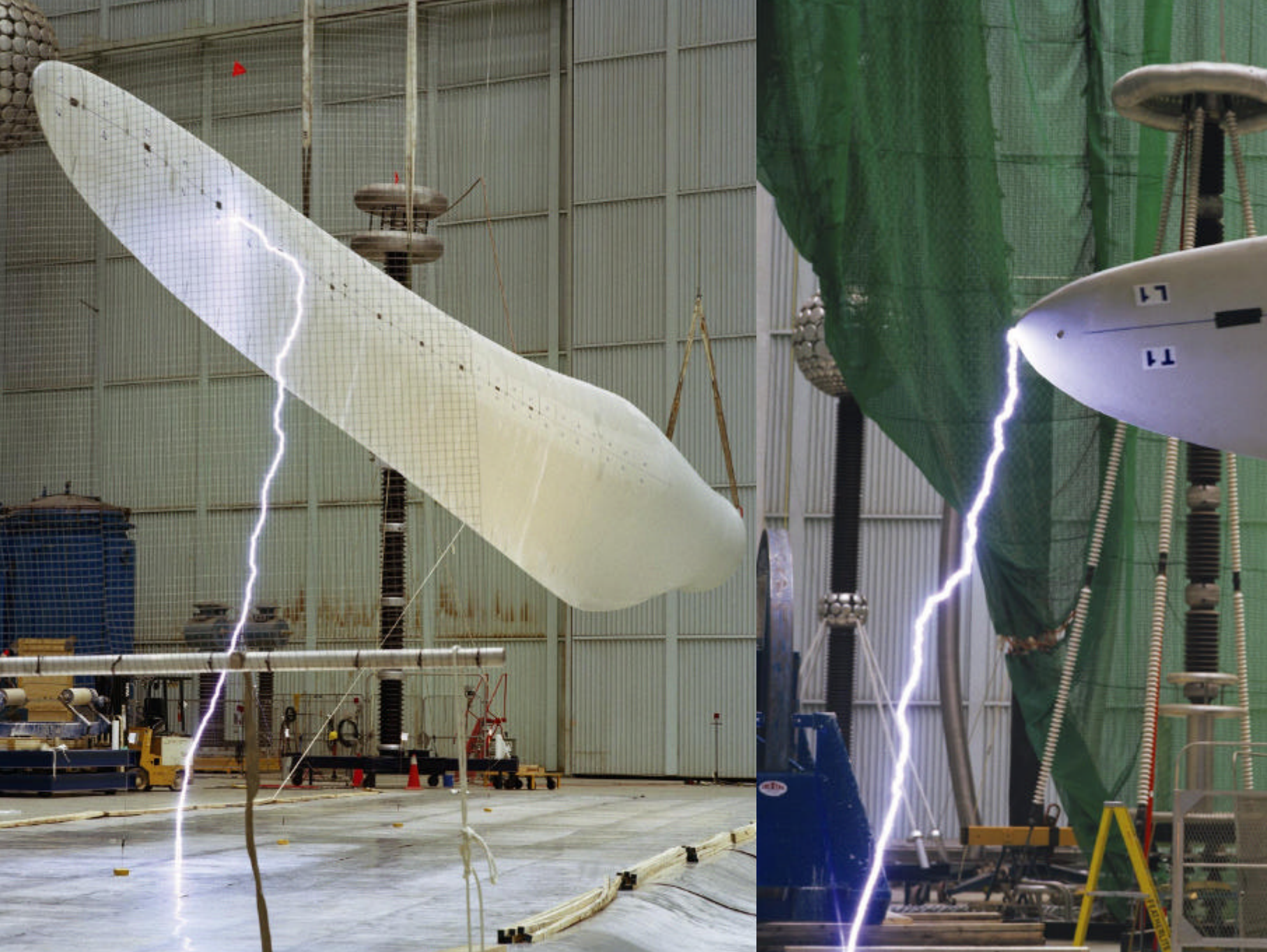
Solution for blades with carbon fibers

LM Lightning protection for large rotor blades

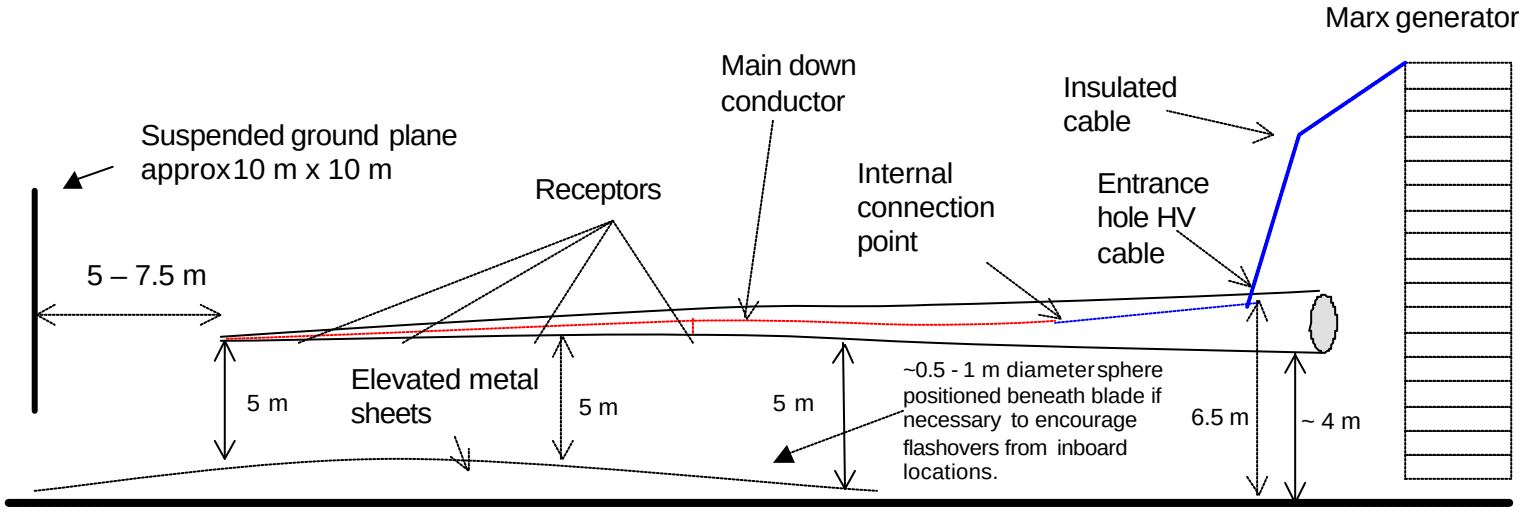
Multi Receptors mounted on both side of the blade

Drain Receptor

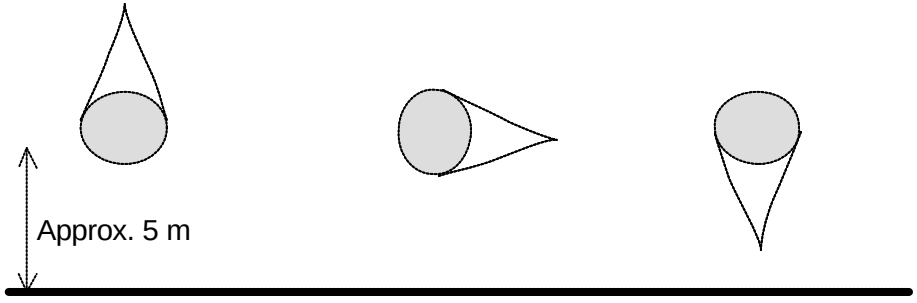
Conductive cable


L1
T1

LM test setup

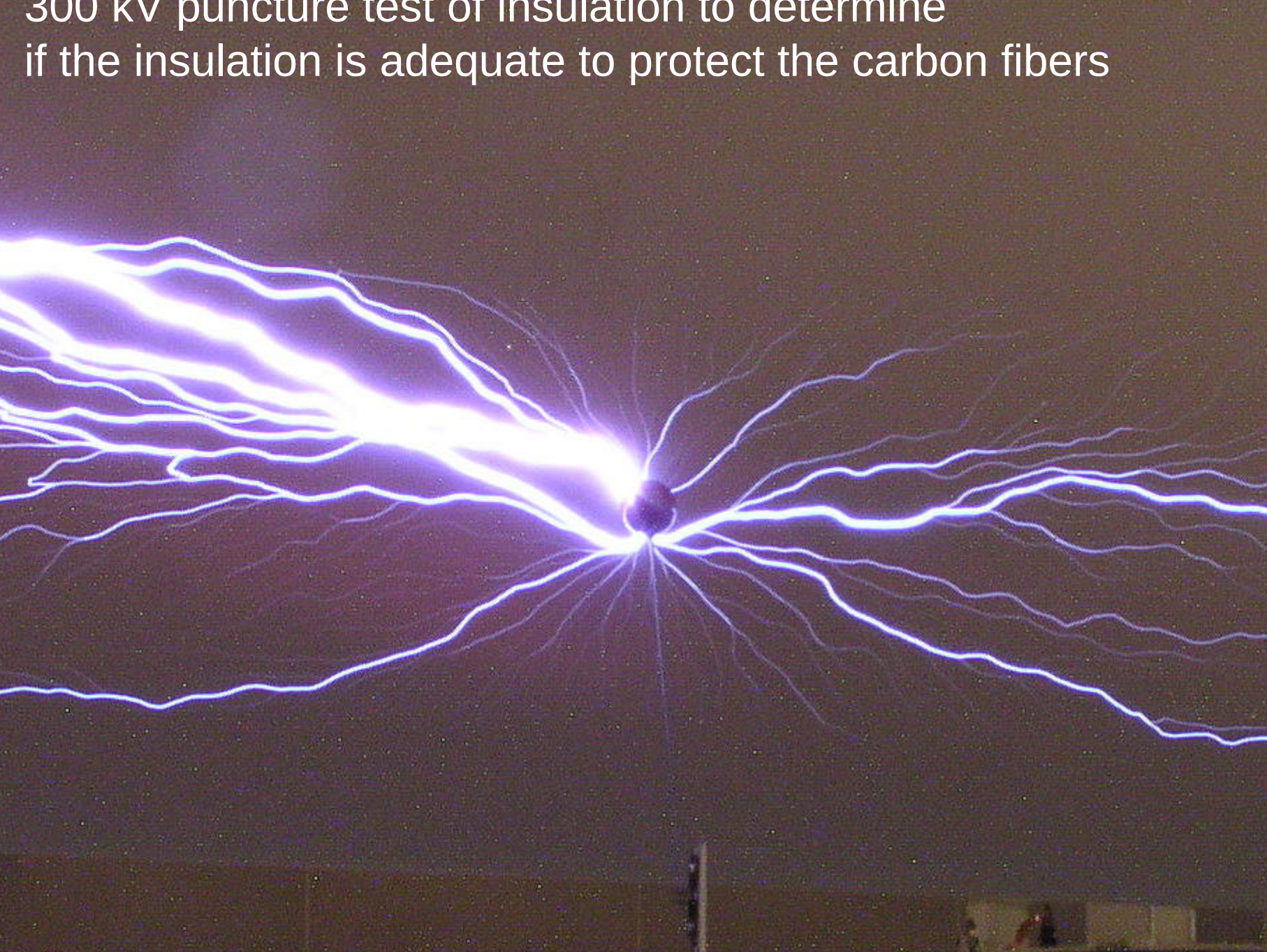


Side view of blade: A vertical 10 m x 10 m ground plane is shown suspended 5 – 7.5 m in front of the blade tip.



End views of the blade in the 3 different angles it was tested in

300 kV puncture test of insulation to determine
if the insulation is adequate to protect the carbon fibers



Carbon fibers are conductive – but manageable

- Carbon fibers are semi conductors and hard to protect =>
- LM chooses to let the carbon be an active part of the Lightning Protection System
- Blades with carbon fibers are tested according to ED105 EuroCAE CEI/IEC 611312-1 protection level I

Blade monitoring track record

Lightning Registration Card

Has been installed in more than 45,000 blades

1996

First passive monitoring system of lightning incidents.

Blade Vibration Detection

Surveillance of blade vibrations connected to the wind turbine control system.

1999

First integrated blade vibration detection.

Blade Surface Ice Detection

Blade surface ice detectors Were prototyped in connec-tion with developemt of a Blade deicing system.

2000

Ice detection for blade deicing system.

Black-box system

First generation of LM Blade Monitoring.

More than 50 wind turbines have the Black-box system in Operation.

2002

First integrated blade monitorin system.

The Sensor system

Background

1. Bigger wind turbines

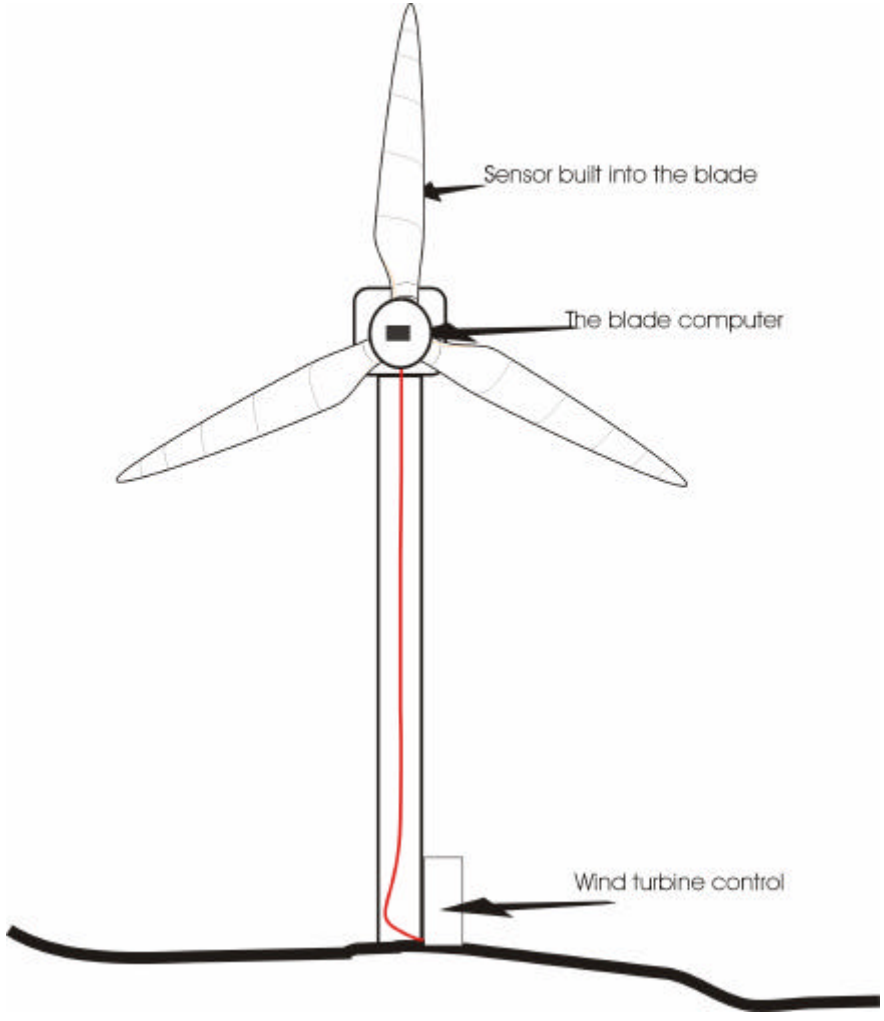
2. Offshore wind farms

3. Increased demands for safety on the production

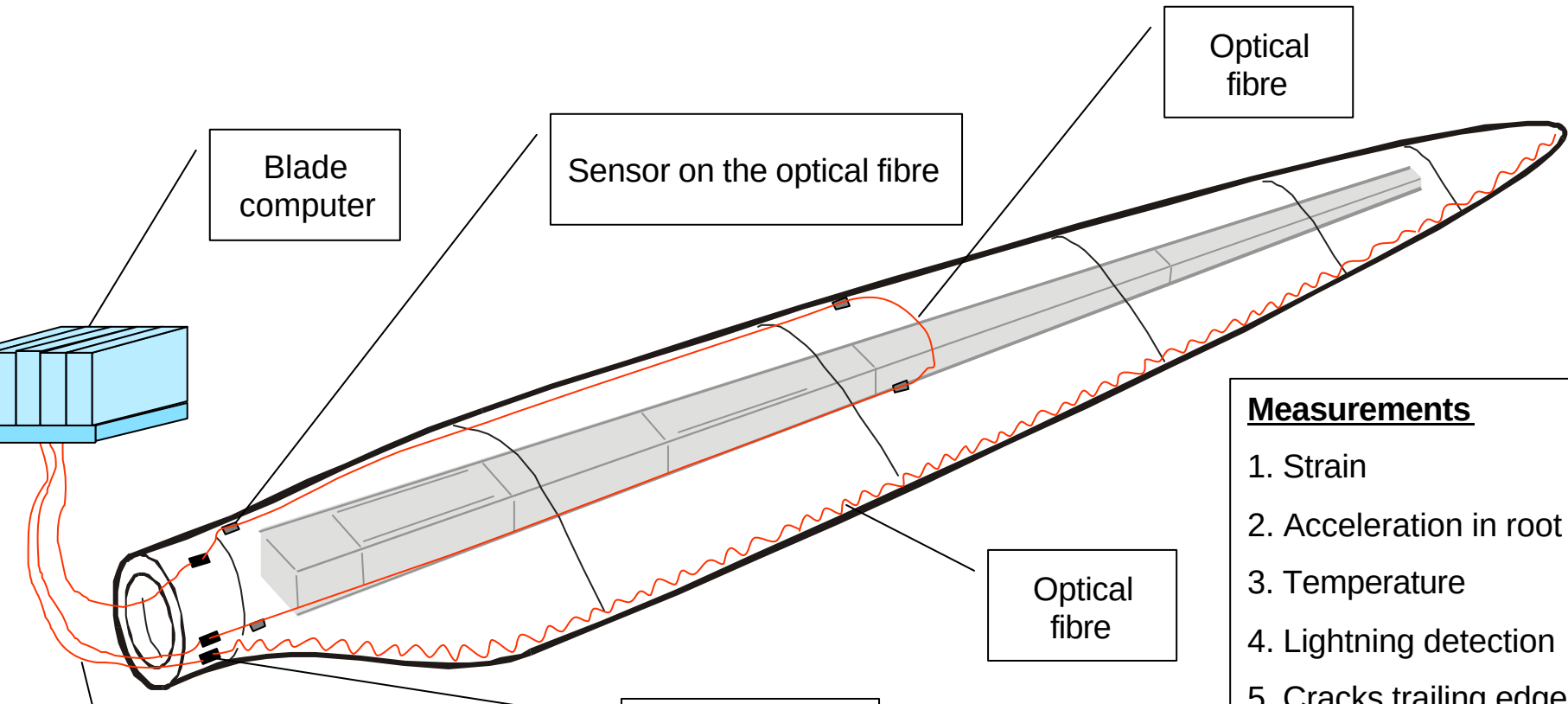
Project Idea

1. Equip the rotor with a blade computer and the blades with sensors

2. Convert the process data to clear information which can contribute to optimise the production and maintenance



Measurements



Measurements

1. Strain
2. Acceleration in root
3. Temperature
4. Lightning detection
5. Cracks trailing edge

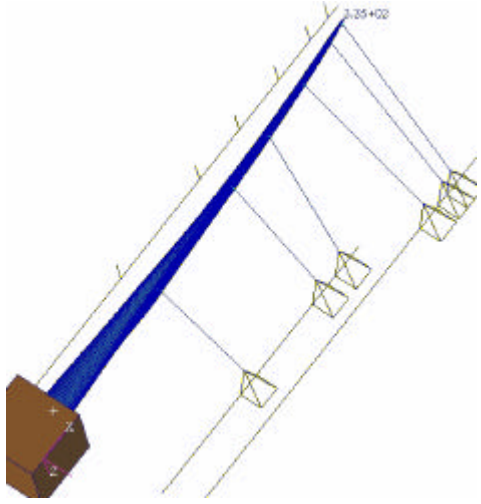
LM Blade Computer - Historic load reports

Historic load reports

Download load reports

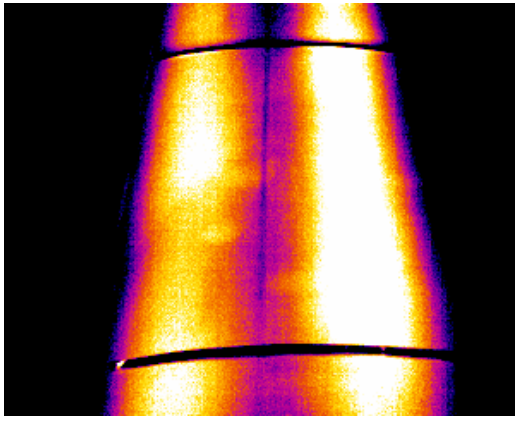
Operation assurance and long product lifetime through integrated test program

- The only rotor blade manufacturer with internal full scale test facilities. More than 11010 dynamic full scale tests of blades are carried trough.
- Den present capacity are able to test rotor blades until 65 m and 30 MNm
- Simulation of 20 years operation, including external actions, during 6 month (depending of type of blade)
- Random test of the running production of the hole blade and components
- Extensive NDT (Non Destructive Testing) program, which employs infrared and ultra sound scanning
- Accredited blade test facilities



Future blade test program.

Operation assurance and long product lifetime through integrated test program



Q’s & A’s

Presentation can be downloaded in at www.lm.dk

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